health worker from colleagues.

Libraries, hospitals and other organizations often lack adequate funds or foreign currency to subscribe to medical journals or to maintain on-going subscriptions. Health workers are also hindered from sharing information with each other about issues because of the high cost of telephone calls, fax services and travel.

The goal of HealthNet's information services is to connect the health worker with a range of information options in a cost-effective manner with the most affordable and appropriate technology. South-South, North-South and South-North information sharing and distribution is supported by HealthNet. These services continually evolve in response to the needs and resources of HealthNet users.

UNIQUE SERVICES

Many of these services are not available in any other electronic form through other sources in the countries served by HealthNet, including: electronic publications, bibliographic search of the National Library of Medicine (NLM) in Washington, D.C., United States, and library partnerships.

HealthNet News, other electronic publications

These publications, compiled by SatelLife or produced by collaborating organizations, cover topics that are of interest and relevance to those who work in health in the developing world.

HealthNet News features current clinical medical information. Summaries, abstracts, short reports, and some full text articles from many journals are included with permission from publishers. Distribution is limited to HealthNet users in developing countries.

African Medical Librarians Bulletin (AMLB) is made possible by contributions by African medical librarians. It contains selected tables of contents as well as abstracts from local and regional medical publications.

WHO Library Digest for Africa is edited by the staff of the World Health Organization (WHO) Library in Geneva. This publication includes WHO material of interest to librarians and health workers in the developing world.

WHO/AFRO Infodigest is compiled by the Documentation Centre in Brazzaville, Congo, and highlights tropical diseases and other health issues.

AIDS Bulletin, compiled by SatelLife, includes clinical information on HIV/AIDS including STD's. Distribution is limited to HealthNet users in developing countries.

Mothers and Children contains information concerning the health and nutrition of women and children. It is the electronic form of the same publication produced by the American Public Health Association.

Population Issues features information on population, family planning and reproductive health.

Batch Internet NLM Information System (BITNIS)

SatelLife is collaborating with the NLM and the Pan-American Health Organization (PAHO) to test, demonstrate, and train users in BITNIS in medical libraries and research centres in HealthNet countries in Africa. HealthNet users are provided BITNIS access at reduced rates comparable to those charged students in the United States.

BITNIS is a data base search tool which allows users to do automated searches of 21 abstract data bases at the NLM. Searches are prepared on Grateful Med, a software package developed by the NLM. The search strategy is saved, then sent via an e-mail network, such as HealthNet, to the BITNIS gateway at the NLM. The actual search is performed by a computer and the results are returned to the user. Abstracts and bibliographic references are available in the data bases; full text articles cannot be obtained.

The average cost for a search is approximately $1.00-$3.00, and many times may even be considerably less. The searches are performed very quickly by a high-speed computer. The time taken to perform the search depends on how well the search has been defined.

Library partnerships

SatelLife initiated the Library Partnership Program which now facilitates access to medical literature for libraries in the developing world. This programme is largely a volunteer effort and depends on the creation of "partner library" relationships between institutions and medical librarians. Users request searches for abstracts and/or full text articles through their national librarian which are fulfilled regionally or by the international partner librarian.

ADDED VALUE FOR MEDICINE

Other services, while not unique, provide added value by gathering a developing-world medical community through networking: developing-world access; "listservs" or conferencing; referral to experts, data bases, and Internet resources; and distance learning support.

Developing-world access

HealthNet users can send electronic mail to their colleagues nationally, regionally and internationally. For example, using his or her computer, a health care worker in a rural hospital can send a message to a colleague in a neighboring district, in the region, or to an institution

located in another part of the world. Conversely, electronic mail allows easy access from physicians and researchers in developed countries to colleagues in developing countries.

Several internationally-funded projects use HealthNet to provide access to their colleagues in developing countries; for example, WHO's Special Programme for Research and Training in Tropical Diseases (TDR) has supported expansion of HealthNet into Asia. The first phase implementation in Asia includes TDR-related institutions in the Philippines, Sri Lanka, and China.

Conferences: medical-content listservs

Among many "listservs", or e-mail distribution services, operated by HealthNet, the following are examples of important medical information services provided in this way. These electronic conferences allow HealthNet users around the world to form discussion groups on issues pertinent to their immediate needs and/or their professional interests. Conferences provide an interactive format allowing users to either follow or participate in "conversations" irrespective of time and place. Examples include: a) ProMED: Program for Monitoring Emerging Diseases; b) HIV/STD; and c) E-Drug: Essential Drugs

PROMED: PROGRAM FOR MONITORING EMERGING DISEASES

Numerous recent episodes of emerging and re-emerging infections, including the continuing spread of dengue viruses, the now frequent appearance of hitherto unrecognized diseases such as the hemorrhagic fevers, and the resurgence of old scourges like tuberculosis and cholera in new, more severe forms, attest to our continuing vulnerability to infectious diseases throughout the world.

Many experts, both within and outside government, have warned of the need to improve capabilities for dealing with emerging infectious diseases. The development of an effective global infectious disease surveillance system has been the primary recommendation of expert analyses.

ProMED was set up specifically to plan and promote a global system of early detection and timely response to disease outbreaks. Proposed by the Federation of American Scientists, a public policy research organization, ProMED was inaugurated in September 1993 at a Geneva conference co-sponsored by 60 prominent experts in human, animal and plant health. The conference called for a coordinated global programme and charged the ProMED Steering Committee with the task of designing it. Members of the ProMED Steering Committee come from all over the world and include representatives of the WHO, the United States Centers for Disease Control and Prevention, the United States National Institutes of Health, and International Epizootic Organization, as well as other organizations and academic institutions.

In cooperation with SatelLife and HealthNet, ProMED has inaugurated an e-mail conference system on the Internet to encourage timely information sharing and discussion on

emerging disease problems worldwide. Through HealthNet, this low-cost system reaches participants in developing countries and remote areas. Subscription to the ProMED e-mail conference is free of charge.

HIV/STD ELECTRONIC CONFERENCE

The overall goal of this project is to reduce the burden that isolation imposes on health care workers in the developing world who struggle with limited resources to treat a flood of patients with HIV/AIDS or related sexually transmitted diseases (STDs). SatelLife, through HealthNet, will create and administer a global network for HIV and STDs by means of electronic conferencing, so that physicians, health care workers, and policy makers from the developing world can be linked with colleagues in the industrialized world and in their own regions. This project will provide the first electronic mail conferencing for clinicians and researchers in HIV/STDs throughout the world with particular emphasis on engaging those from the developing world. In the struggle against HIV/AIDS, information and communication can save scarce resources, offer a wider range of treatment possibilities, and influence prevention efforts.

E-DRUG: ESSENTIAL DRUGS MAILING LIST

The objective of "E-DRUG" is to support the concept of essential drugs by improving and speeding up communications between all health professionals working in the field of essential drugs. Colleagues in developing countries often cannot afford telephone and fax lines. Normal postal services are too slow and unreliable. Many have already discovered the usefulness of e-mail as an affordable tool for communication. E-DRUG is a free service of SatelLife, and will only cost the normal costs of sending/receiving ordinary e-mail messages.

The list "Who is where on e-mail in essential drugs?" has been maintained by Wilbert Bannenberg for over a one year and contains more than 266 names people and organizations associated with essential drug information. E-DRUG has been specially designed for colleagues in countries without access to interactive Internet tools such as WWW, gopher, USENET and FTP.

E-DRUG is used in the following ways: a) to send a question to all members (e.g., requesting suggestions as how to lobby Parliament or the Medical Association etc.); b) to request a list of available files from E-DRUG (e.g. "Who is where on e-mail in essential drugs"); c) to inform all members about a new reports: *Essential Drug List*, *National Drug Policy*, *Standard Treatment Guideline*, etc.; d) to allow subscribers to receive a regular bulletin highlighting new developments and recently available files; e) to receive publicly available information sources (e.g., WHO/DAP publications, the Model WHO Essential Drug List, the UNIPAC Essential Drug price list, articles from the Essential Drug Monitor or INRUD News).

The primary language of E-DRUG is English, but similar systems could be opened in Spanish (MEDICAM-E) or French (E-MED) if there is enough interest.

OTHER SERVICES

Access to Data Bases and Experts

HealthNet users cannot usually afford, nor do their local telecommunications environments permit, direct or on-line access to international data bases. SatelLife has secured permission from the NLM to make many of its data bases such as Medline, Toxnet, Cancerlit, and others accessible via e-mail search vehicles such as BITNIS. Access to some data bases are fee related.

Distance Learning

HealthNet's technology lends itself to distance learning applications through e-mail, distribution of health information, and electronic conferencing.

Internet Resources

HealthNet offers pointers to useful health mailing lists, World Wide Web homepages, Gopher and FTP sites on the Internet. Sites will be screened so that offerings will be appropriate for users with or without direct Internet access.

COMMUNICATION TECHNOLOGY SERVICES

HealthNet is intended to function reliably and inexpensively, especially in areas where there are poor or non-existent telecommunications infrastructures, using technology available in these locations. Much of the inspiration and technology for HealthNet was taken from amateur-radio communications, which has developed a wide variety of low-cost technologies, many involving personal computer systems. These experimental data communications systems are used only for personal hobby communications in the United States and Europe, but are often the only communications systems available to medical workers in developing countries.

LEO microsatellites HS-1, HS-2

The HealthNet satellite system offers Internet message services to any remote area or areas where the local telecommunication infrastructure is poor or inefficient. SatelLife began in 1989 with the concept of delivering a communications alternative for medical information, that used a LEO amateur packet radio technology satellite to link medical education centers in Africa with medical libraries and other centers in the United States, Canada, and Europe. At that time, the poor telecommunications infrastructures made it impossible to establish electronic mail linkages directly between most African countries. A "store and forward" microsatellite was thought to be the best solution to address both the issues of cost of telecommunications and the problems with poor infrastructure. The alternative solution envisioned use of the LEO satellite as a relay between each ground station in the South, serving as a national hub for e-mail and other data communications, and major medical research and education centres in the North. Satellite acquired Healthsat-1 (HS-1) to begin experimenting with this service on amateur

frequencies.

In the Fall of 1991, SatelLife began its initial demonstration project with the installation of five experimental ground stations in eastern Africa -- Kenya, Mozambique, Tanzania, Uganda and Zambia -- and the establishment of its Internet gateway at Memorial University, St. John's, Newfoundland, Canada. It was expanded to an additional 10 countries by the International Development Research Centre in Canada and funded as research in health communication. Problems of physical installation and operation, and automation of software, were solved to create a system providing e-mail: every ground station acts as a post office node, which can be accessed on the ground via telephone and modems for delivery and pick-up of messages. Prior to each satellite pass, messages are bundled by ground station destination and prepared for satellite uplink. Any mail destined for addressees on other systems was gatewayed into the global Internet at the Canadian station and vice versa.

Small networks were envisioned in each country, which would link key health related institutions such as the Faculty of Medicine, medical library, ministries of health, NGOs, offices of the WHO and the United Nations Children's Fund (UNICEF), etc. The computer centres at the initial five universities were identified as key collaborators, where hub stations or nodes were licensed by the PTTs. The users of this network were expected to number in the dozens, and message traffic among the ground stations was expected to be well within the capabilities of the satellite network.

Despite problems with equipment and software, HS-1 usage grew very rapidly; users soon numbered in the hundreds in some networks and message traffic grew to nearly 1 megabyte per day. Growth would clearly have continued. However, the limited capacity of the satellite was insufficient to meet the demand. It was decided that the first satellite would be replaced by a second more powerful satellite, Healthsat-2 (HS-2), with similar technology, operating on frequencies allocated for commercial operation. United States licensing for use of these frequencies is a long process, and in the interim, experimental licensing at the Memorial University Center for Telemedicine, St Johns, Newfoundland, Canada, was used to continue experimentation. In the interim, international dialed telephone data communications was provided to support the demonstrated need and demand.

The current HealthNet satellite (HS-2) is a LEO satellite capable of store and forward full-duplex communication at 9,600 bps. The satellite was launched in a polar orbit which means that the satellite will have passes (crossings of the sky) in any location around the globe. Locations close to equator will have four passes per day, with each pass lasting for about 13 minutes. Due to the sun-synchronous orbit, the satellite passes will occur around the same time every day -- two passes around 10 AM and two passes around 10 PM. The satellite has one downlink and two uplink communication channels. There can be several users requesting messages from the satellite, but only two users can send messages to the satellite at one time.

The ground equipment needed to contact the satellite consists of an IBM-PC compatible computer, a Terminal Node Controller (TNC), a satellite radio and antennas. At this stage,

SatelLife is testing a new radio design that merges the satellite radio and the TNC into a single portable box. The new system was tested in the field at the North Pole in the spring of 1995, by the International Arctic Expedition led by Will Steger which was sponsored by the National Geographic Society. The experiment showed that small portable equipment for LEO-based store-and-forward message services have a unique role in communications to remote regions.

For the user, the HealthNet software is similar to any e-mail offline reader/writer software. The system permits messages addressed to Internet destinations, to any other satellite station or to any other HealthNet user. Binary files may be attached to messages or transferred by separate file request. All routing and delivering is transparent to the user.

Low-cost amateur PC message networks (FIDO)

The LEO satellite was initially expected to be an essential tool for the solution of the communications problems in developing countries because phone circuits, when they existed, were not good enough to allow reliable transmission of data. Since then, modern telephone switching equipment has been installed in many cities in Africa, providing good international connections, and sophisticated error correcting modems make data transfer possible even in places where the phones do not work well. Because of these rapidly evolving technologies, dialed telephone circuits and error correcting modems are often a more economical and efficient solution for international transfer of electronic data in developing countries than our microsatellite. FIDO message networks, which developed in an amateur experimenter community similar to that of amateur radio, during the growth of the Internet, provide an economical alternative to Internet e-mail systems, with equal or better services. FIDO networks were in widespread use in Africa in the 1980's and SatelLife joined the many NGOs supporting their use. The organization is committed to supporting this low-cost access system with advanced Internet services, brought as close as possible to the end-user.

The evolution of Healthnet has produced a large network of FIDO message network nodes, some using a packet radio satellite for transport of message files, with central routing of messages to and from FIDO networks and the Internet at a Sun UNIX computer located in Cambridge, Massachusetts, United States. The network is still growing rapidly, although much of its growth is in the "points" connected to network nodes rather than in the nodes themselves. The service is affordable for organizations in the developing world because phone calls placed at the Cambridge hub are billed at United States rates rather than rates set by PTTs. The cost of international calls are presently subsidized by private and corporate donations and foundation grants. The organization is beginning to move these telecommunications expenses and other costs of operation to a cost-recovery basis, in order to eventually make HealthNet self-sustaining.

HEALTHNET-II

Where communications facilities are intermittent, of poor quality, or expensive, the most efficient way of using them is by data communications transmission of digitally encoded messages rather than direct "real-time" voice or fax connections. SatelLife therefore has put

Local archiving and indexing, and full-text retrieval, of electronic publications is also possible at UNIX servers, especially CD-ROM-based publications as available. Within copyright restrictions, it may also be possible to provide e-mail-server access to such search tools.

BITNIS access to the United States NLM is a useful tool, but requires a great deal of experience to formulate accurate and efficient searches. This experience is best obtained by interactive use of the NLM databases directly through Grateful Med. This is a software tool

running on Internet host computers at the NLM, accessible only through full Internet connections via "telnet". SatelLife is investigating the use of scheduled dialup Internet connections (originated in the United States to minimize costs) to support classroom use of a shared Internet connection, for BITNIS/Grateful Med training in Africa.

Distance education support is one of the most intriguing applications of advanced Internet services. Hypertext Markup Language (HTML), a formatting tool for documents used in the World Wide Web (WWW) graphic display interfaces now familiar to many researchers in developed countries, is designed for linkage of related brief documents in a way that is ideal for presentation of a structure of related pages for interactive self-education. Although most of the use of Web tools is for presentation of graphic images, some software exists that can present the HTML text components of a Web page on a text-only screen, or with limited graphics, on a DOS PC screen. In addition, local dialup modem access to a serial line on a UNIX system can function as a BBS for self-education and DOS PC Web software can be packaged with educational material prepared for it on a diskette, for stand alone use.

SatelLife is investigating a specific application of this HTML-based technology to interactive presentation of diagnostic flowcharts, as an element of a future project for the Global Initiative on Asthma (GINA).

Added value for medicine

Many Internet users in developed countries have asked how they can affiliate themselves with HealthNet to support its work, or to have access to SatelLife's electronic publications. SatelLife is developing an electronic directory service to provide electronic mailbox "aliases" for existing electronic mail addresses on other networks, which can be made available to such users as individual affiliate subscribers.

One aspect of this directory service that can lead to more flexible e-mail use among HealthNet users is its ability to record other identifying attributes, e.g. professional specialization fields, along with personal and e-mail routing attributes. These could be used to support e-mail list distribution with much greater flexibility than that of our present listserv.

The Internet now is closely identified with WWW Web page interactive access. The costs of interactive international Internet WWW access are prohibitive for anything but a large campus or national network connection to the global Internet, even with a subsidy, and are out of reach for many public health users. Local Web page "mirroring" of selected Web pages in developed countries may make it possible to provide access to important sources of information otherwise unavailable, especially to users on networks in medical schools and teaching hospitals.

SatelLife is investigating ways to provide Internet interactive services on schedule or on demand via international dialed modem link, at affordable costs. Added costs of international communications require accounting and cost recovery, so the problems involved are not entirely technical.

SatelLife continues to explore ways of making advanced services accessible through store-and-forward services, "plain old e-mail", by servers at UNIX machines for such advanced Internet services as FTP and gopher. As indicated above, bibliographic searching applications of e-mail servers are also under consideration.

User support services

SatelLife has always attempted to provide good documentation to support HealthNet users, who often are just beginning to explore serious uses of their computers. It will provide multi-lingual printed and embedded documentation, and online documentation in conference or newsgroup form.

An e-mail support desk service has always been available at SatelLife, but in an informal fashion. We plan to improve problem tracking, resolution, and response to originators of problem reports. With Internet services available at field locations, many of these support activities can be handled effectively by staff and volunteers in the developing world. We also plan improved response to voice and fax calls to SatelLife, with an off-hours support policy.

User directory servers

With UNIX systems in field as well as central locations, it may become possible to provide User Councils with flexible HealthNet user group directory services, including central United States or European billing for NGOs with operations in many locations, aliased "healthnet.org" addresses for existing e-mail addresses, and flexible e-mail lists using affiliation by directory attributes including project or sponsor concern, professional concern, regional/local/national concern, or an ad hoc group concern.

Conferences/newsgroups

SatelLife plans to provide access to selected Internet "newsgroups" and other sources of similar material from collaborating organizations, as available for open distribution. Limited distributions similar to our electronic publications may also be available to specific destinations; e.g. HealthNet-only newsfeed, or distribution to medical campus networks.

IMPROVED INTERNET INTEGRATION

As a provider of Internet electronic mail addresses, each HealthNet is an Internet service. However, there are distinct "levels" of Internet capability, and e-mail only services have the fewest capabilities. We plan to offer HealthNet User Councils the opportunity to upgrade their networks to improve services without requiring users to dismantle their existing software and buy new computer hardware.

Conventional Internet technology

Since 1993, SatelLife has operated the Internet domain "healthnet.org", to support access by its member networks. The Sun Microsystems UNIX computers that support this domain are located at the Department of Telemedicine, Memorial University, St Johns, Newfoundland, and at the organization's headquarters in Cambridge, Massachusetts. Internet backbone service via New England Academic and Research Network (NEARNet) has been provided by Bolt, Beranek, and Newman Inc. (now BBN Planet Inc.), which in 1995 graciously donated 56KB leased line service to us in recognition and support of SatelLife's work.

The success of the global Internet, in capturing the imagination of the development community, has led to a strong demand for high-speed Internet Protocol (IP) services between developing countries and the United States and Europe. While the cost barriers of providing international permanent leased lines are still prohibitive for most public health and medical education programmes in developing countries, there are now several cases in which IP access is a realistic alternative to store-and-forward networks, and SatelLife is investigating ways to help our member networks take advantage of these circumstances as they arise.

Personal computers are now affordable and available worldwide, but PC software poses many problems for Internet service operations, which are typically based on the more complex UNIX engineering software system. In the past two years, public domain software for UNIX on PCs has become a stable and respected (and very low-cost) alternative to commercial UNIX system software. SatelLife is working to bring together TCP/IP networking, AX.25 packet satellite ground station, and FIDO components into an automated system that we can help nonspecialists support. Our own engineering task will be to provide software to simplify control and monitoring of this package, so that the amount of UNIX-specific experience and training required is kept to a minimum. To accomplish this task, SatelLife is exploring partnerships with technical universities in Europe, Canada, and the United States.

This new network node technology should not affect current users of our FIDO network, but will offer each HealthNet Users Council many new options in Internet services to campus networks where they exist, including local and international UUCP and TCP/IP connections as available, and will make each HealthNet more useful and attractive to users of standard Internet mail systems. The change from FIDO to a UNIX node will be the User Council's decision, and thus the global HealthNet will gradually evolve into a new "HealthNet-II" in which Internet technology provides a wide range of advanced interactive information services to meet developing countries' medical information needs.

FIDO network technology

FIDO message networks, which developed in an amateur experimenter community similar to that of amateur radio, during the growth of the Internet, provide an economical alternative to Internet e-mail systems, with equal or better services. FIDO networks were in widespread use in Africa in the 1980s and SatelLife joined the many NGOs supporting their use there. There

are now thousands of Africans using FIDO network systems daily for routine business and personal communications, and many services providing access to the Internet through FIDO networks.

It is recognized that this installed base of e-mail users is not likely to change to non-FIDO systems -- in large part because they cannot afford to upgrade the older computer systems that can run the FIDO mail software -- and SatelLife is committed to supporting this low-cost access system with advanced Internet services, brought as close as possible to the end-user. SatelLife is investigating the use of existing software tools which are used for FIDO-Internet gateway systems, for a viable solution that can be installed in a UNIX system in the field to support a local HealthNet's FIDO access needs. At the same time, SatelLife is investigating support of user access by similar UNIX-based software systems using "UUCP", and dialup Internet Protocol (IP), and with such systems the local HealthNet node can support access with any of these, depending on the quality and cost of local phone service.

HealthSat-II network for remote access

HealthSat-II (HS-2) is an amateur radio technology satellite using the same basic communications components, both on the satellite and in the ground station, as with HS-I, but as a mature example of this type of system it is sufficiently more powerful in several respects that its capabilities are significantly improved. At the time of its launch, the manufacturer, Surrey Satellite Technology Ltd. of the United Kingdom, described HS-2 as a "state-of-the-art" microsatellite and the "culmination" of its work in store-and-forward communications; this description seems appropriate. A comparison is contained in Table 1.

HS-2 presents an opportunity for the development of a communications system in support of health care and development for remote, rural, and mobile locations, providing national and regional e-mail message services, with a gateway to the global Internet in the national capital or regional center. There are two, fundamentally different types of HS-2 ground stations: a) a "terminal" ground station, low-power, integrated with control software in a general-purpose PC computer for greatly improved ease of use; and b) a "hub" ground station, high-power, attached to a multiprogrammed dedicated communications computer (also a PC, but larger and more powerful, using UNIX system software) serving as an access system for other computers but not primarily as a user message terminal.

In HealthNet-II, the hub serves as a gateway for e-mail and other Internet services using a variety of communication technologies. In general, the HS-2 link does not serve as the only access to the rest of the network and the following options are also available: a) HS-2 satellite message transport to HS-2 national/regional terminal ground stations (and backup international message transport); b) international direct dial modem: UUCP and PPP (TCP/IP) access; c) local direct dial modem: UUCP, FIDO, PPP access; d) AX.25 VHF packet radio; and e) HF radio data link.

Single 8MHz 80C186 communications processor	Dual redundant 8MHz 80C186 communications processor
1802 COSMAC control processor (36KB program memory addressable)	10MHz 80C188 control processor (1MB program memory addressable)
4MB CMOS RAM with ERCC memory error protection	48MB (3 x 16MB) SRAM with EDAC memory error protection
Experimental (amateur secondary) frequencies	General mobile-satellite frequencies (as of 1992 WARC)
Switchable 1200/9600 bps link speed	1200/9600 bps uplink, 9.6Kbps/38.4Kbps downlink
Open-access AX 25 PACSAT protocol system	Open-access AX.25 PACSAT protocol system; revised "New Uplink Protocol (NUP)" was deliverable December 1993. AX.25 and NUP operation will both be available concurrently in service.
Age: 5.5 years, past 3 years without failure	Age: 2 years, no major failures
Estimated lifetime: 10+ years based on 11.5 years of UoSAT-2	Estimated lifetime: 10+ years

HS-2, with the NUP protocol upgrade, is expected to make it possible for multiple transactions between the hub and a number of terminals within a single pass, so that delays in message delivery within the nation or region, and in forwarding to the global Internet, are minimized.

Table 1

HealthSat-I (HS-1)	HealthSat-II (HS-2)
One uplink receiver, one downlink transmitter	Three uplink receivers, two downlink transmitters
4W nominal output power; 3W typical	Output transmitter power selectable from 1W to 12W under software control. (+6dB improvement over HS1)
Single 8MHz 80C186 communications processor	Dual redundant 8MHz 80C186 communications processor
1802 COSMAC control processor (36KB program memory addressable)	10MHz 80C188 control processor (1MB program memory addressable)
4MB CMOS RAM with ERCC memory error protection	48MB (3 x 16MB) SRAM with EDAC memory error protection
Experimental (amateur secondary) frequencies	General mobile-satellite frequencies (as of 1992 WARC)
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HS-2, with the NUP protocol upgrade, is expected to make it possible for multiple transactions between the hub and a number of terminals within a single pass, so that delays in message delivery within the nation or region, and in forwarding to the global Internet, are minimized.

SatelLife is currently developing this hub communications system by testing the Linux public-domain operating system and public-domain communications software (some of it from the same amateur-radio community that developed AX.25 and the PACSAT protocols). Windows-based software for terminal ground stations from the same community, will make it possible for SatelLife to develop the terminal ground station with confidence in its flexibility, reliability, and ease of use. HS-2 can then provide a viable "last-mile" Internet communications solution as originally intended.

Surface amateur-packet-radio message network for regional access

To improve upon its ability to provide developing countries with low-cost, effective telecommunications, SatelLife is investigating digital store-and-forward communications via High Frequency (HF) and Very High Frequency (VHF) packet radio, as a practical tool to provide Internet message service to HealthNet users in remote regions.

Like LEO satellite technology, HF allows for linking remote locations served by poor or non-existent telephone service. Unlike LEO satellites, HF radio links can provide telecommunications for longer periods of time than a typical 15-minute satellite pass. HF radio propagation is highly variable, depending upon the time of day, time of the year, sunspot activity, and other naturally occurring phenomena, but paths of up to 1,000 km can be maintained over long periods of time, using modest power levels with good antenna systems.

Incorporating HF as a networking solution is a great challenge because HF reception is noisy and erratic, and as a result it is considered by many to be an outdated, obsolete method of communication. However, HF is enjoying a resurgence of popularity due in part to recent advancements in digital technology and linking methods. Research and development is no longer restricted to government-sponsored programmes. Many commercial manufacturers in Europe and the United States now offer a variety of PC-compatible data modems to address this technology. The rapid commercial development is being fueled in part by interest among the world's radio amateurs.

SatelLife's HF network may employ automatic linking technology based on Automatic Link Establishment (ALE) standards. ALE operates on one of a group of radio frequencies, with on-going measurement of channel quality by comparing the signal-to-noise ratio and the bit error rate. If either the signal-to-noise or bit error rates rises to unacceptable levels ALE will direct the linked stations to a different frequency in the group that is more favourable to present propagation conditions.

To complement ALE, SatelLife is studying two forms of data modem technology: CLOVER, which allows for various bandwidth-efficient combinations of discrete amplitudes and phases; and PACTOR: an improved version of AMTOR which responds well to changing channel conditions. A network of one or more HealthNet HF stations can link to a central "hub" or gateway, typically located in a capital city, linked to the global Internet via campus network high-speed links or dialed modem connection.

In addition to HF radio, SatelLife is also exploring VHF radio networking solutions. Unlike HF, VHF radio is short-range (up to 100 km) in nature. It is typically used in "line-of-sight" applications. VHF is limited in applications where natural obstructions, such as mountains, lie in the signal path. However, VHF does not suffer from erratic propagation phenomena like HF. Thus, paths are more reliable and noise-free, and higher data rates can be sustained. In some instances links can be maintained 24 hours per day. This permits the use of TCP/IP Internet protocol systems over VHF links, with speeds approaching that of leased lines. SatelLife is investigating use of amateur packet radio networking software in "Linux" UNIX software for PCs to provide regional access to hospital and campus LANs as well as to the global Internet.

To complement in-house packet radio work by its engineering staff, SatelLife has established a working relationship with individual engineers at the Mitre Corporation, Bedford Massachusetts, who are following the organization's progress with interest.

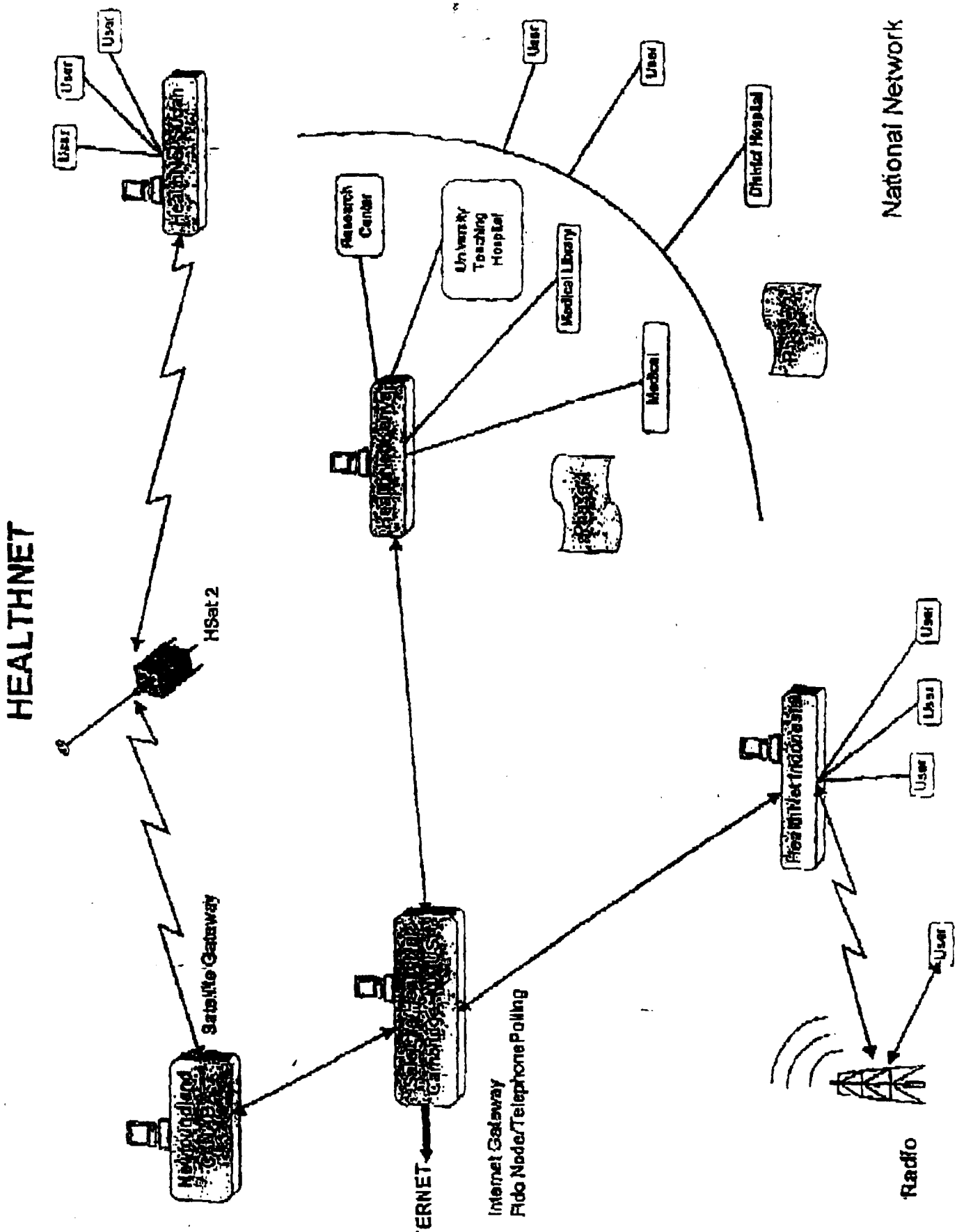
SUMMARY: NEW DIRECTIONS IN HEALTHNET TECHNOLOGY AND INFORMATION SERVICES

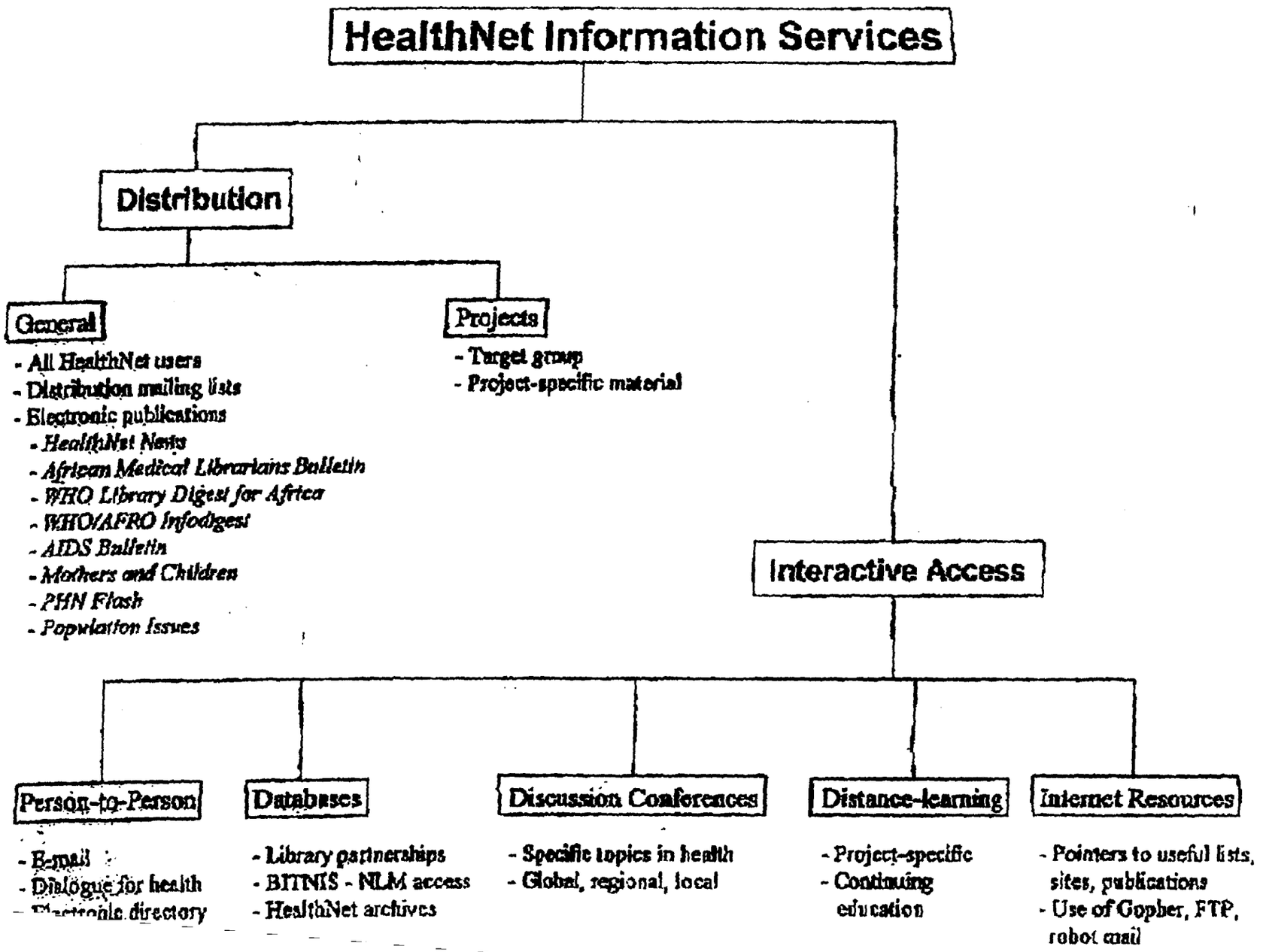
This successful network is more than a demonstration. It has become an essential service to many of its users. SatelLife plans to add to its software and hardware to add services, control and reduce costs, and improve reliability. However, this is only an intermediate step in the development of this network, because health care needs and technology opportunities make it necessary to constantly reevaluate its operation. SatelLife is currently at an important point in this development, because changes in satellite technology, and opportunities in radio technology, and the approach of Internet connectivity to African universities, mean that this network for routing messages will become increasingly diverse and technologically complex.

The only practical approach to handling this complexity with software that can automate enough of the message service operations to make it feasible to operate with non-specialist staff, is to base the system on a powerful multi-programming engineering software environment such as UNIX which has become the standard tool for solving these types of problems. UNIX is likely to become an increasingly central part of our software repertoire, although hopefully not increasingly visible to message service users. The change from FIDO to a UNIX node will be the User Council's decision, and thus the global HealthNet will gradually evolve into the new HealthNet-II.

One of the biggest problems in this evolution is training network managers in the new technology. SatelLife will provide training and support upon installation, and will plan for interim direct operations support from Cambridge. In collaboration with university programmes in the United States, Europe, and Canada, SatelLife will encourage development of university curriculum in developing countries, in engineering, computer science, and telecommunications, and other technical training programmes, in directions that will familiarize students (including our network managers) with the problems and new solutions we are dealing with. We believe the availability of public domain UNIX for PCs is an extremely important tool for this educational revolution in Africa and other less-developed regions. Although our resources are

limited, we will support network managers that can use such software in such a programme, to familiarize themselves and others with UNIX and Internet technology.


HEALTHNET
National Network
HSat 2
Satellite Gateway
INTERNET
Internet Gateway
Fido Node/TelephonePolling
Radio
User
Research Center
University Teaching Hospital
Medical Library
Medical
Clinical Hospital


HealthNet Information Services
Distribution
General
- All HealthNet users
- Distribution mailing lists
- Electronic publications
- HealthNet News
- African Medical Librarians Bulletin
- WHO Library Digest for Africa
- WHO/AFRO Infodigest
- AIDS Bulletin
- Mothers and Children
- PHN Flash
- Population Issues
Projects
- Target group
- Project-specific material
Interactive Access
Person-to-Person
- E-mail
- Dialogue for health
- Electronic directory
Databases
- Library partnerships
- BITNIS - NLM access
- HealthNet archives
Discussion Conferences
- Specific topics in health
- Global, regional, local
Distance-learning
- Project-specific
- Continuing education
Internet Resources
- Pointers to useful lists, sites, publications
- Use of Gopher, FTP, robot mail

Certificate of Service

I, James A. Kirkland, hereby certify that the foregoing "Petition to Deny" was served by hand this 27th day of November, 1996, on the following persons:

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